Journal of Dental Sciences (2016) 11, 225–230

Available online at www.sciencedirect.com

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journal homepage: www.e-jds.com

Journal of Dental Sciences

ORIGINAL ARTICLE

The prevalence of antral exostoses in the maxillary sinuses, evaluated by cone-beam computed tomography

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Received 10 April 2015; Final revision received 31 July 2015
Available online 2 July 2016

KEYWORDS
cone-beam computed tomography;
exostosis;
maxillary sinus

Abstract *Background/purpose:* Exostoses are outgrowths of normal compact and cancellous bone and may occur in different locations of the jaw. Exostoses are a rare anatomic variation in the maxillary sinuses. The purpose of this study was to investigate retrospectively the prevalence of location, size, shape, and symmetry of exostoses in the maxillary sinus, and to assess the relationship between demographic variables (i.e., age and sex) via cone-beam computed tomography images.
Materials and methods: Cone-beam computed tomography images of 1000 patients [521 (52.1%) females and 479 (47.9%) males], aged 10–85 years (mean age, 44 years), were examined. Two investigators examined the exostoses for location (i.e., inferior wall, medial wall, lateral wall, or posterior wall of the maxillary sinuses), size, shape (i.e., broad-based or mushroom-like), and symmetry (i.e., unilateral or bilateral). The age of the patients was categorized into three groups: 10–30 years, 31–50 years, and 51+ years. The data were statistically analyzed by using chi-square test, Fisher's exact test, and the t test.
Results: In total, 52 exostoses from 48 patients (4.8%) were identified. Exostoses were more common in females ($n = 28$, 58.3%) than in males ($n = 20$, 41.7%); however, there was no statistically significant difference between the sexes ($P > 0.05$). The presence of exostoses was very similar for all age groups with no statistically significant differences ($P > 0.05$).
Conclusion: Most exostoses were unilateral and on the inferior wall of the maxillary sinus. No statistically significant difference existed between the frequency and location of exostoses for sex or age groups ($P > 0.05$).

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http://dx.doi.org/10.1016/j.jds.2015.10.004

Introduction

Exostoses are outgrowths of normal compact and cancellous bone and may occur in different locations of the jaws.[1] Maxillary and mandibular tori are the most common exostoses in dentistry. Exostoses are rare; however, they—as well as hypoplasia, pneumatization, and septa—are an anatomic variation in the maxillary sinuses. Several authors have investigated antral exostoses. In the otolaryngology literature, Ramakrishnan et al[2] first reported this entity in 2010; however, in 1993 in the dental literature, Ohba et al[3] investigated the prevalence of antral exostoses in panoramic radiographs and reported a prevalence of 0.9%. However, this relatively new diagnostic entity was disregarded by investigators until 2010, after which the subject attracted the attention of dentists and otolaryngologists.

The etiology and mechanisms of oral exostoses are unclear and there is no consensus among the investigators. Various authors have suggested several etiological factors such as genetic traits, environmental factors, mastication and occlusal stress, inflammation, systemic diseases, and the postmenopausal period.[4–9] The investigators of numerous studies have concluded that a strong association exists between parafunctional activity (e.g., clenching, grinding teeth, and/or bruxism) and the presence of mandibular tori, whereas maxillary tori shows no such association.[10–12] The presence of mandibular tori may be a useful indicator of parafunction and/or increased risk of temporomandibular disorders.[10,11] In addition, parafunctional activity could cause the formation of mandibular tori by concentrating mechanical stress in the region in which mandibular tori usually form.[12] Some authors emphasized a possible autosomal dominant inheritance with a lower penetrance,[5,13,14] whereas other authors have reported a correlation between oral exostoses and bruxism, temporomandibular dysfunction,[4,15–17] and inflammation of gingival tissue.[7]

The maxillary sinus is close to the orbita, alveolar ridge, and maxillary posterior teeth. Thus, this anatomical region may sustain injuries during dental procedures. The maxillary sinus elevation technique is a very commonly used strategies for dental implant rehabilitation in the atrophic posterior maxilla.[18–20] The assessment of several alterations in maxillary sinuses is especially essential in preoperative implant placement to the maxillary posterior region because the maxillary alveolar process forms the maxillary sinus floor.[21] An antral exostosis is an alteration in the maxillary sinus, and these formations may especially complicate the sinus elevation procedures planned before preoperative implant placement in the edentulous posterior maxilla. Therefore, before the preoperative implant planning, it is essential to evaluate the presence of antral exostoses and other alterations in the maxillary sinuses.

Several reports exist in dentistry and otolaryngology literature regarding this entity.[2,3,22–25] However, published articles on antral exostoses are mostly case reports or studies investigating incidental findings and/or pathologies in the maxillary sinuses.[2,20–26] To our knowledge, only two studies have analyzed the prevalence of antral exostoses.[3,26] A 1993 report by Ohba et al[3] via panoramic radiographs focused only on the prevalence of antral exostoses. Panoramic radiography allows visualization of the maxillary sinuses and incidental findings; however, superimpositions of the cranial structures may negatively affect the diagnostic accuracy of maxillary sinus examinations. Cone-beam computed tomography (CBCT) is a helpful diagnostic tool to identify anatomical variations and maxillary sinus abnormalities without superimpositions.[27]

The purposes of this study were to investigate the prevalence, location, size, and shape of antral exostoses and to assess the relationship between demographic variables (i.e., age and sex), and to determine the symmetry of antral exostoses between contralateral sides in the same patient.

Materials and methods

This retrospective study was approved by the Ethical Review Board of the Faculty of Dentistry, Ankara University (Tandoğan/Ankara, Turkey). Informed consent was routinely obtained from all patients before their clinical and radiographic examinations. The initial material study consisted of the demographic data (i.e., sex and age) and the CBCT images of 2385 patients who applied to the Department of Dentomaxillofacial Radiology, Faculty of Dentistry, Gazi University (Emek-Ankara, Turkey) between January 2013 and November 2014. The CBCT images of the patients were included in the study, provided the following criteria were met: (1) the patient had no trauma and/or history of head surgery; (2) the maxillary sinuses could be visualized; (3) the maxillary sinuses had no lesions; and (4) the CBCT images were of good quality and free of artifacts. Thus, after exclusion, 1000 CBCT images were included in the study.

The CBCT images were obtained using a Promax 3D unit (Planmeca, Helsinki, Finland), which was operated at 84 kVp at 9–14 mA and with a 0.16-mm voxel size, exposure time of 6 seconds, and a field of view of 8 cm. The images were examined by the consensus of one experienced oral radiologist (OD) and one oral radiology resident (GA). The CBCT images were analyzed using inbuilt software (Romexis viewer 2.7.0; Planmeca) on a 24-inch Nvidia Quadro FX 380 screen (Nvidia, Santa Clara, CA, USA) with 1280 $\times$ 1024 resolution in a quiet room with subdued ambient lighting. The observers were allowed to manipulate the contrast and brightness features and to use the zoom tool of the software for optimal visualization. The axial, sagittal, and cross-sectional slices (thickness, 1 mm) of CBCT images were used. All observers were blinded to the sex and age of the patients.

The antral exostoses were evaluated for location (e.g., inferior wall, medial wall, lateral wall or posterior wall of the maxillary sinuses), size (mm), and shape (i.e., broad-based or mushroom-like).[3] The symmetry (i.e., unilateral or bilateral) of antral exostoses between contralateral sides in the same patient, and the side (i.e., right or left) were also recorded. The sizes in the mesiodistal, inferosuperior, and anteroposterior directions of the antral exostoses were measured in millimeters.[3,25]

The age was categorized into three groups: 10–30 years old, 31–50 years old, and 51+ years old. The obtained data were statistically analyzed by using crosstabs and descriptive statistics, the chi-square test, the Fisher's exact test, and the *t* test. A P value = 0.05 was considered as the level of significance.

Results

In total, 2000 maxillary sinuses of 1000 individuals [521 (52.1%) females and 479 (47.9%) males], aged 10–85 years (mean ± standard deviation, 44.3 ± 15.8 years), were examined. Fifty-two antral exostoses existed in 48 patients (mean ± standard deviation, 41.1 ± 15.6 lesions) and the prevalence was 4.8%. All exostoses were in the maxillary sinuses adjacent to dentate maxillary alveolar process.

Antral exostoses were more common in females (*n* = 28, 58.3%) than in males (*n* = 20, 41.7%); however, there was no statistically significant difference between the sexes (P = 0.461). With regard to the age groups, the presence of antral exostoses was very similar [for the 10–30 years and 51+ years age groups, *n* = 17 (32.7%); for the 31–50 year age group, *n* = 18 (34.6%)]. There was no statistically significant difference (P = 0.379).

Most antral exostoses were on the inferior wall of the maxillary sinuses, followed by, in decreasing order, the lateral, medial, and posterior walls. Statistically significant differences existed between the locations of the antral exostoses (chi-square = 38.923, df = 3, P = 0.000). No statistically significant difference (i.e., P > 0.05) existed between the locations of the antral exostoses for sex and age groups (Table 1). Most antral exostoses were unilateral (*n* = 44; 91.7%). Bilateral exostoses occurred in only four patients (*n* = 4; 8.3%).

The sizes of antral exostoses in the different directions were longer in females than in males. The size of antral exostoses were commonly decreased in the elderly. However, with regard to age and sex, no statistically significant differences (P > 0.05) existed in either direction (Table 2). The antral exostoses with a broad base were more common than those with a mushroom-like shape, and the difference was not statistically significant for age and sex (Table 3; P > 0.05).

Discussion

Limited information exists regarding the prevalence of antral exostoses.[3,26] First, Ohba et al[3] used panoramic radiographs to research the incidence of antral exostoses in 1993. They found 20 (0.9%) exostoses in 2197 investigated panoramic radiographs. Another study by Lana et al[26] used the CBCT scans of 500 patients to define various maxillary sinus abnormalities, including antral exostoses, and reported a prevalence of 2.6%. In the current study, we used the CBCT scans of 1000 patients to define the prevalence of antral exostoses. We found exostoses in 48 individuals, therefore, the prevalence was 4.8%. The relatively low rates reported in the other two studies can be explained by the radiographic technique and research methods they used. Panoramic radiography is a useful method to view the maxillary sinuses,[18] however, the superimposition of other facial structures and because it is a two dimensional method, means panoramic radiography is an inadequate technique for examining the maxillary sinuses.[28] The relatively low prevalence in the study by Lana et al[26] can be explained by their research method. Their study was not focused on antral exostoses only; they also investigated other anomalies in the maxillary sinuses. To the best of our knowledge, this study is the first to research the prevalence of antral exostoses using CBCT.

Table 2 The means, standard deviations, and statistical analysis of the size of the antral exostoses in different directions, according to age and sex.

The size of the antral exostoses in different directions	Age (y) and sex	Mean (mm)	Standard deviation	P
Inferosuperior	10–30	2.65	2.04	0.199
	31–50	3.63	2.23	
	51+	2.88	1.45	
Mediolateral	10–30	2.96	1.55	0.909
	31–50	3.30	2.05	
	51+	2.71	0.84	
Anteroposterior	10–30	2.35	1.14	0.193
	31–50	3.62	2.58	
	51+	2.88	1.29	
Inferosuperior	Female	3.36	2.28	0.526
	Male	2.66	1.32	
Mediolateral	Female	3.30	1.77	0.183
	Male	2.58	1.12	
Anteroposterior	Female	3.05	2.12	0.759
	Male	2.85	1.45	

Table 1 The distribution and statistical analysis of the location of antral exostoses, according to age and sex.

Age and sex		Localization of antral exostoses				P
		Inferior wall	Medial wall	Lateral wall	Posterior wall	
Age group (y)	10–30	13 (76.5)	1 (5.9)	3 (17.6)	—	0.123
	31–50	9 (50)	4 (22.2)	2 (11.1)	3 (16.7)	
	51+	10 (58.8)	2 (11.8)	5 (29.4)	—	
Sex	Female	15 (50)	6 (20)	6 (20)	3 (10)	0.111
	Male	17 (77.3)	1 (4.5)	4 (18.2)	—	
Total		32 (61.5)	7 (13.5)	10 (19.2)	3 (5.8)	

The data are presented as *n* (%).

Table 3 The distribution and statistical analysis of the shape of antral exostoses, according to age and sex.

Age and sex		Shape of antral exostoses		P
		Broad-based	Mushroom-like	
Age groups (y)	10–30	15 (88.2)	2 (11.8)	0.709
	31–50	14 (77.8)	4 (22.2)	
	51+	14 (82.4)	3 (17.6)	
Sex	Female	23 (76.7)	7 (23.3)	0.332
	Male	20 (90.9)	2 (9.1)	
Total		43 (82.7)	9 (17.3)	

The data are presented as *n* (%).

The etiology of bone exostoses is unknown, but multifactorial genetic and environmental factors may have a role.[4–17] Bone metabolism is influenced by various cells formed in the bone marrow such as mesenchymal stem cells, osteoblasts, osteoclasts, stromal cells, and adipocytes.[4] In some systemic diseases, the balance between bone metabolism cells may be changed and abnormal functions of osteoblasts, osteocytes, and osteoclasts occur.[1,4] Thus, the overall catabolic state in bone may be affected.[4,29–31] The sympathetic nervous system innervates bone tissue, and its activity inhibits bone formation. It has been reported that certain drugs such as antihypertensives that inhibit the activity of the sympathetic nervous system counteract the catabolic state and increase bone mineral density and bone formation.[32–34] Morrison et al[4] reported the association between treated hypertension and the presence of oral torus. Some authors report that oral exostoses may be correlated with increased bone mineral density in postmenopausal women.[5,6] Published articles regarding the etiology of oral exostoses focused on the origin of only mandibular and maxillary tori.[4–17] There is no report on the etiology of antral exostoses in maxillary sinuses in the literature. With regard to antral exostoses in the maxillary sinuses, some authors advocate a possible correlation between cold temperature nasal irrigation, cold-water swimming, and antral exostoses.[22,23] These procedures may be environmental factors that cause stress in the maxillary sinuses just as mastication and occlusal stress may cause stress for mandibular and maxillary tori. Most previously published cases ($n = 6$; 85.7%) in the literature are associated with a long history of cold temperature nasal irrigation, cold-water swimming, sinusitis, and maxillary sinus surgery,[22–24] with symptoms such as discomfort, pain, and inflammation. It has also been reported that the patients kept nasal irrigants in the refrigerator.[2,22,23] There was no symptom in the reported cases, except for one case ($n = 1$; 14.3%).[24] There was no information about whether individuals with antral exostoses had any symptoms. This lack of information was a limitation of the present retrospective study.

The study by Ohba et al[3] concluded with a 2.3:1 female to male ratio. The number of individuals with antral exostoses had a female predilection in published case reports (Table 4). Antral exostoses have been reported in individuals 22–66 years old.[2,20–25] In our study, this ratio was 1.4:1 with a female predominance, but no statistically significant difference existed between the sexes. In the present study, antral exostoses occurred in individuals aged 20–69 years. Some published literature concluded that exostoses (i.e., maxillary and mandibular tori) are associated with increasing age.[9,35] Jainkittivong and Langlais[9] reported that exostoses appear to be stable during the middle phases of life (30–59 years), and increase slightly at the age of 60 years and older. This finding contrasts with Sonnier et al[36] who noted that the prevalence of exostoses decreased after 50 years of age, and they correlated this decreasing trend with edentulism. In the literature, there is no information concerning the difference between antral exostoses and atrophic/edontolous posterior maxilla, whereas in the current study all cases were detected on the dentate maxilla.

Case reports by Ramakrishnan et al[2] and Schwartz et al[24] described bilateral exostoses, although the case report by Borie et al[25] described unilateral lesions. There were no bilateral exostoses in the research by Ohba et al.[3] In the study by Lana et al,[26] only 15.4% of lesions were bilateral. We found bilateral exostoses in 8.3% of the patients.

Ohba et al[3] found that the average size of these lesions was 4.7 mm × 7.4 mm. Borie et al[25] in their case report defined the size of these lesions as 6.3 mm × 9.8 mm in the right sinus and 15.4 mm × 9.4 mm in the left sinus.[25] The relatively low average dimensions of the lesions in our study can be explained by the difference between the radiographic techniques used. We were able to define the smallest lesions because CBCT is a three-dimensional radiographic method and there is no superimposition.

Schwartz et al[24] reported cases of lesions on the superior wall of the maxillary sinus, and Borie et al[25] reported cases of lesions on the inferior wall. Ohba et al[3] defined most lesions on the inferior wall. This finding was consistent with our results. The reason for this finding can be explained by the formation mechanism of these entities.

Some authors indicate that these lesions are the consequence of long term cold nasal irrigations.[22,23] As a result of the gravitational movement of fluid through the sinus floor, lesions may be more common in the inferior wall. In accordance with previous reports, we found most antral exostoses on the inferior wall of the maxillary sinuses. As we examined the shape of the lesions, 80% of the lesions were broad-based in the Ohba et al study[3]; we found 82.6% of the lesions were broad-based.

Table 4 Clinical data of reported cases.

Published reports	Age (y)	Sex	Sinus involved
Ramakrishnan et al (2010)[2]	38	Male	Bilateral
Schwartz et al (2012)[24]	57	Male	Bilateral
Haffey et al (2012)[22]	52	Male	Bilateral
	65	Male	Bilateral
	44	Female	Bilateral
	48	Female	Bilateral
	57	Female	Bilateral
Adelson et al (2013)[23]	50	Female	Unilateral
	63	Female	Unilateral
	57	Male	Bilateral
	22	Female	Unilateral
Borie et al (2014)[25]	49	Female	Bilateral

Differential diagnosis of the antral exostoses should be performed with anthroliths, foreign bodies, osteomas, and septa in the maxillary sinuses. Anthroliths and foreign bodies existing in the maxillary sinuses generally have a radiolucent border between the maxillary sinus floors. Septa residing in the sinus floor are bony outgrowths, which are continuous along the sinus, and osteomas have distinctive borders. The appearance of antral exostoses in the maxillary sinuses differ from the aforementioned lesions on CBCT images. This entity is characterized by single or multiple small nodular masses of increased density within the maxillary sinus attached to the wall and the sinus walls show diffuse, smooth remodeling and thickening on CBCT. We defined the lesion as an exostosis, based on its relationship between the maxillary sinus floor, continuity, and boundary of the radiopacity.

Antral exostoses generally do not require surgical approaches. A biopsy examination is not usually suggested, unless the antral exostosis causes clinical symptoms and leads to sinonasal obstruction. However, a biopsy could be useful in some patients with an inconsistent history or noncharacteristic-appearing lesions.[22]

In conclusion, this study is the first to describe the prevalence, shape, location, and size of the antral exostoses using CBCT. We found lesions were relatively more common than reported in other studies. Any surgical approach to the maxillary sinus requires three-dimensional imaging before an operation, based on the higher prevalence that we detected.

Conflicts of interest

All contributing authors declare no conflicts of interest.

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